
5 QUALITY ASSURANCE PROCEDURES

Random Numbers

Design Mix Formula

Mixture Adjustment Factor

Lot/Sublot -- QC/QA HMA

Acceptance Samples

Adjustment Period -- QC/QA HMA

Mixture Acceptance

QC/QA HMA

HMA

Pay Factors -- QC/QA HMA (Dense Graded Mixture \geq 1 Lot)

PWL - Mixture

PWL – Density

Pay Factors

Adjustment Quantity -- QC/QA HMA \geq 1 Lot

**Pay Factors -- QC/QA HMA (Dense Graded Mixture $<$ 1 Lot
and Open Graded Mixtures)**

Mixture

Density

**Adjustment Quantity -- QC/QA HMA < 1 Lot and Open
Graded Mixures**

Mix Appeal -- QC/QA HMA

CHAPTER FIVE:

QUALITY ASSURANCE PROCEDURES

The acceptance criteria for QC/QA HMA set out in the Quality Assurance Specifications are based on binder content, air voids @ N_{des} , VMA @ N_{des} , density and smoothness. The Specifications establish controls for temperature of the mixture, testing of aggregates for quality, and testing of binder. The acceptance criteria for HMA mixtures are based on binder content and air voids. The acceptance criteria for SMA mixtures are binder content and gradation.

This section includes the procedures for obtaining acceptance samples, minimum requirements for mixture properties in accordance with Sections **401** (QC/QA HMA), and **402** (HMA) and the procedures for determining pay factors.

RANDOM NUMBERS

Sampling for mixture tests is done on a random basis using **ITM 802**. A table of Random Numbers, as shown in Figure 5-1, is used to determine the random quantity or random location. The numbers occur in this table without aim or reason and are in no particular sequence. Therefore, samples obtained by the use of this table are truly random or chance, and eliminate any bias in obtaining samples.

To use the random number table to determine the random ton to sample, select without looking one block in the table. After selecting the block, the top left number in the block is the first random number used. This number is the beginning number. Proceed down the column for additional numbers and proceed to the top of the next column on the right when the bottom of the column is reached. When the bottom of the last column on the right is reached, proceed to the top of the column at the left. If all numbers in the table are used, select a new starting number and proceed in the same manner.

To use this table to determine the location of the pavement sample, again select a block in the table and start with the top left number. This number is used to determine the test site station. The adjacent number within the block is used to determine the transverse distance to the random site. Proceed down by pairs until the bottom numbers are reached and proceed to the adjacent top block to the right, if available. When the bottom pair of numbers on the right are reached, proceed to the top block on the left in the table.

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.310	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.246
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.218	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Figure 5-1. Random Numbers

DESIGN MIX FORMULA

The Producer is required to submit for the Engineer's approval a Design Mix Formula (DMF) for each mixture. This information is recorded in a format acceptable to the Engineer. TD-451 is one format that has been used for this purpose (Figure 5-2). INDOT is required to have a signed copy of the DMF prior to production of any mixture.

MIXTURE ADJUSTMENT FACTOR

A Mixture Adjustment Factor (MAF) is used to adjust the mixture planned quantity and lay rate prior to paving operations, and the pay quantity upon completion of production of the mixture. The MAF is calculated by dividing the maximum specific gravity (G_{mm}) from the mixture design by the following values:

<u>Mixture</u>		
9.5 mm	--	2.465
12.5 mm	--	2.500
19.0 mm	--	2.500
25.0 mm	--	2.500

If the calculated MAF is equal to or greater than 0.980 and equal to or less than 1.020, the MAF value is considered to be 1.000. If the calculated MAF is less than 0.980, then 0.020 is added to the value. If the calculated MAF is greater than 1.020, 0.020 is subtracted from the value. The planned quantity and lay rate are adjusted by multiplying by the MAF. The accepted quantity for payment is adjusted by dividing by the MAF.

Example:

Mixture	=	9.5 mm Surface
Planned Quantity	=	9750.00 tons
Placed Quantity	=	9500.00 tons
Mix Design G_{mm}	=	2.360
Lay Rate	=	165 lb/yd ²

$$\text{MAF} = \frac{2.360}{2.465} = 0.957$$

$$\text{MAF} = 0.957 + 0.020 = 0.977$$

$$\text{Adjusted Planned Quantity} = 0.977 \times 9750.00 = 9525.75 \text{ tons}$$

$$\text{Adjusted Lay Rate} = 0.977 \times 165 \text{ lb/yd}^2 = 161 \text{ lb/yd}^2$$

$$\text{Adjusted Pay Quantity} = \frac{9500.00}{0.977} = 9723.64 \text{ tons}$$

The MAF does not apply to open graded mixtures.

LOT/SUBLOT -- QC/QA HMA and SMA

Quality Assurance Specifications consider a lot as 5000 t of Base or Intermediate QC/QA HMA, and 3000 t of Surface QC/QA HMA or SMA. The lots are divided into five sublots of equal tons. For Base and Intermediate QC/QA HMA therefore, a subplot is 1000 t, and for Surface QC/QA HMA or SMA, a subplot is 600 t. Partial sublots of 100 t or less are added to the previous subplot. Partial sublots greater than 100 t constitute a full subplot. Partial lots of four sublots or less are added to the previous lot, if applicable.

ACCEPTANCE SAMPLES

Sampling of mixture for acceptance is made from the pavement in accordance with **ITM 580**. INDOT determines the random site and the Contractor obtains the samples under INDOT supervision. INDOT takes immediate possession of the samples.

A specific ton in each subplot is selected and the mixture from the truck containing that ton is sampled. This truck is determined by checking the weigh tickets. An example of how to determine what ton is to be sampled is indicated on form TD 452 (Figure 5-3). These random tons are not shown to the Contractor so that there is no possible influence on the construction operations.

Once the truck that contains the random ton is identified, the approximate total length of mixture that the truck places is determined by knowing the weight of the truck, the paving width, and the quantity placed. When placing variable depth, such as a crown correction, the average depth is used. The following relationship is used to calculate this approximate length that a truck would place.

$$\text{Length of Load} = \frac{\text{Load Weight (t)}}{\text{Avg. Planned Quantity (lb/yd}^2\text{)} \times \text{Width of Paving (ft)}} \times 18000$$

(Nearest Foot)

**INDIANA DEPARTMENT OF TRANSPORTATION
MATERIALS AND TESTS DIVISION
HMA DMF/JMF per 401/402**

HMA PRODUCER :							
PLANT LOCATION :							
CERTIFIED PLANT NUMBER:							
APPROVED DESIGN LAB :							
Aggregate Size	Source	Source #	Q-Number	Ledges	%	Dolo. Test (YES/NO)?	Sample Per _____ Tons of HMA

PG BINDER	Source	Source #	Binder % RAS	Binder Replacement %	Virgin Binder %
			0.00%	0.00%	0.00%
Additives/ Fibers/ Etc.	Source	Source #			%

DMF number		YYD999			Fine RAP/ Coarse RAP/ RAS in mixture, %				
Comments:					Fine RAP/ Coarse RAP/ RAS binder, extracted, %				
					Ignition oven test temp (°F)				
					Ignition oven calibration factor				
					Ignition oven number				
Base Design PG-Grade					Binder, ignition (actual), %				
Mixture course					Binder, extracted, %				
Mixture designation					Extraction required? Yes* or No				
Maximum particle size		#N/A			Binder, calculated effective, %				
	Spec	DMF Mass	JMF Mass	Volume	Gyrations Nini / Ndes / Nmax				
%Pass 37.5 mm					Mass gyratory pill @ Ndes, g				
%Pass 25.0 mm					Gmm				
%Pass 19.0 mm					Gmm w/ dry back? Yes or No				
%Pass 12.5 mm					Gmm % @ Nini and Nmax				
%Pass 9.5 mm					Gmb @ Ndes				
%Pass 4.75 mm					Air Voids @ Ndes, %				
%Pass 2.36 mm					VMA @ Ndes, %				
%Pass 1.18 mm					VFA @ Ndes, %				
% Pass 600 µm					Coarse agg. ang. 1 & 2 face, %				
% Pass 300 µm					Fine aggregate angularity				
% Pass 150 µm					Sand equivalency				
% Pass 75 µm					Dust/calculated effective binder				
Aggregate blend Gsb					Tensile strength ratio, %				
WMA temp. plant min./max. (°F)					Draindown, % (SMA or OG only)				
HMA temp. plant min./max. (°F)					Date Ignition oven samples submitted				
Mix compaction temp.lab (°F)					VCA _{DRC} /VCA _{MDX} (SMA only >1)				
* Extraction Note - Written request required, submit w / DMF					MAF by DTE for PE/PS		1.000		

PRODUCER: _____ DATE: _____

DTE SIGNATURE: _____ DATE: _____

DTE Notes:
DMF reference history:
Producer Notes:

Figure 5-2. Design Mix Formula

COPIES TO:
DISTRICT TESTING ENGINEER
FILE

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

RANDOM SAMPLING FOR MIX ANALYSIS

Contract No. R-20396 LOT No. 4
District Greenfield Mixture 19.0 mm Intermediate
DATE SAMPLED: SUBLOT 1 6/9/01 SUBLOT 2 6/9/01 SUBLOT 3 6/10/01 SUBLOT 4 6/10/01

SUBLOT NO.	SUBLOT TONS	RANDOM NO.	RANDOM TON	LOT TON TO BE SAMPLED	PAVING WIDTH	RANDOM NO.	TRANS. LOC.	LENGTH OF LOAD	RANDOM NO.	RANDOM DIST.	STARTING STA.*	RANDOM STATION
	A	B	A x B = C	D	E	F	E x F	G	H	G x H = I	J	I + J
1	600			0								N.B. Passing
	1000	.123	123	0	12	.100	1.2 (1)	136	.259	35	10+50	10+85
2	600			625								N.P. Passing
	1000	.116	116	1000	12	.890	10.7 (11)	136	.317	43	76+90	77+33
3	600			1250								N.B. Passing
	1000	.836	836	2000	12	.523	6.3 (6)	136	.665	90	194+00	194+90
4	600			1875								N.B. Passing
	1000	.636	636	3000	12	.928	11.1 (11)	136	.404	55	247+20	247+75

* STATION OF PAVER WHEN TRUCK CONTAINING RANDOM TON BEGINS UNLOADING.

$$\text{Length of Load} = \frac{\text{Load Weight (tons)} \times 18000}{\text{Avg. Planned Quantity (lb./sq. yd.)} \times \text{Width of Paving (ft.)}}$$

Figure 5-3. Random Sampling for Mix

The length the truck places is multiplied by the first random number to obtain a longitudinal distance. This distance is measured from the location of the paver when the truck containing the random ton begins unloading into the paver or material transfer device. The transverse test site location is determined by multiplying the width of pavement by the second random number and rounding to the nearest whole ft. This distance is measured from the right edge of pavement when looking in the direction of increasing station numbers. If the transverse location is less than 1 ft from either edge of pavement, at a location where the course thickness is less than 2.0 times the maximum particle size, or within the width of the roller drum used to form shoulder corrugations, then another random location is selected to obtain an acceptable sampling location. The first 300 t of the first subplot of the first lot for each DMF/JMF is not sampled. If the random ton selected for the subplot is within this first 300 t, then 300 is added to the random ton selected and the sample is obtained from the truck containing that ton. The following example indicates how these random locations are determined.

Example:

Width of Pavement	=	12 ft
Load Weight	=	20 t
Mixture	=	9.5 mm Surface
Planned Quantity	=	110 lb/yd ²
Ending Station of Paver of Previous Load	=	158+00
Random Numbers	=	.256, .561

Test Site Station

$$\text{Length of Load} = \frac{20}{110 \times 12} \times 18000 = 273 \text{ ft}$$

$$\text{Longitudinal Distance} = 273 \times .256 = 70 \text{ ft}$$

$$\text{Random Station} = (158+00) + 70 = 158+70$$

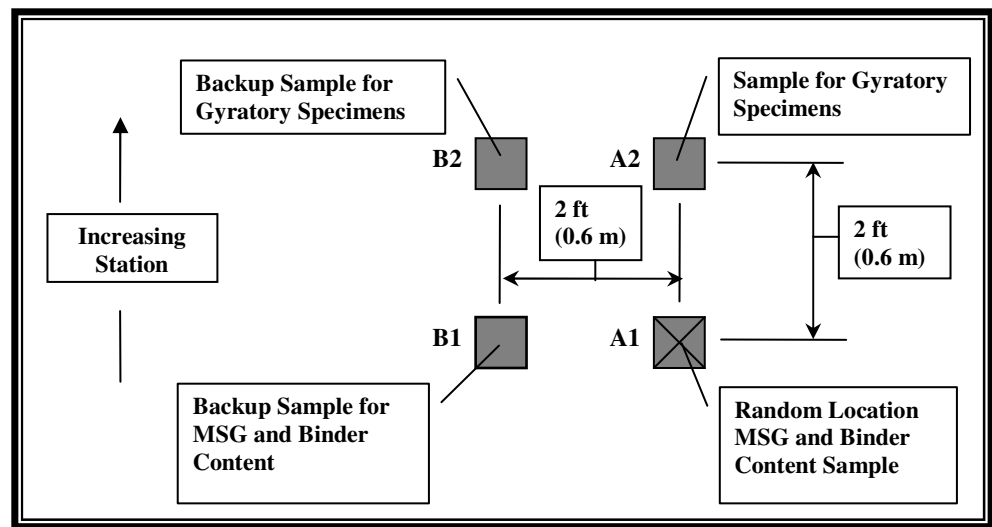
Transverse Distance

$$\text{Distance} = 12 \times .561 = 6.7 \text{ ft (say 7 ft)}$$

For contracts controlled by volumetrics for QC/QA HMA (401), several samples are required. The first plate sample location is determined by the random sampling procedure and this material is used for the maximum specific gravity and binder content samples. This plate is designated A1. A second plate sample is placed longitudinally 2 ft upstation from the first plate at the same transverse offset. This sample is used for the gyratory specimens and is designated A2.

If an appeal by the Producer of the INDOT test results is accepted, backup samples are tested. These samples are obtained at the same time as the acceptance samples. The backup sample plate for the maximum specific gravity and binder content is placed transversely 2 ft from the first plate towards the center of the mat and is designated B1. The backup sample for the gyratory specimens is placed transversely 2 ft from the second plate towards the center of the mat and is designated B2.

The following diagram indicates an example of an arrangement of the plate samples when additional samples are required for QC/QA HMA:



Example:

Width of Pavement	= 12 ft
Load Weight	= 20 t
Mixture	= 9.5 mm Surface
Planned Quantity	= 110 lb/yd ²
Ending Station of Paver of Previous Load	= 158+00
Random Numbers	= .256, .561

Test Site Station

$$\text{Length of Load} = \frac{20}{110 \times 12} \times 18000 = 273 \text{ ft}$$

$$\text{Longitudinal Distance} = 273 \times .256 = 70 \text{ ft}$$

$$\text{Random Station} = (158+00) + 70 = 158+70$$

Transverse Distance

$$\text{Distance} = 12 \times .561 = 6.7 \text{ ft (say 7 ft)}$$

MSG and Binder Content Sample

$$\text{Random Location} = 158 + 70$$

$$\text{Transverse Distance} = 7 \text{ ft}$$

Gyratory Specimens Sample

$$\begin{aligned}\text{Random Location} &= (158 + 70) + 2 \text{ ft} \\ &= 158 + 72\end{aligned}$$

$$\text{Transverse Distance} = 7 \text{ ft}$$

Backup Sample for MSG and Binder Content

$$\text{Random Location} = 158 + 70$$

$$\text{Transverse Distance} = 7 - 2 = 5 \text{ ft}$$

Backup Sample for Gyratory Specimens

$$\begin{aligned}\text{Random Location} &= (158 + 70) + 2 \text{ ft} \\ &= 158 + 72\end{aligned}$$

$$\text{Transverse Distance} = 7 - 2 = 5 \text{ ft}$$

Areas placed with wideners or other specialty paving equipment are not subject to plate sampling. If a random sampling location falls within an area placed by this equipment, another randomly selected location is determined. If an entire subplot falls within an area placed by this equipment, the previous subplot is used for acceptance. If the previous subplot is not available, the subsequent subplot will be used for acceptance.

The size of the plate used to obtain a sample is dependent on the test(s) conducted on the material. The following minimum sample weights are required:

Mixture Designation	Minimum Weights (g)	
	MSG and Binder Content	Gyratory Specimens
4.75 mm	1200	11000
9.5 mm	3000	11000
12.5 mm	4000	11000
19.0 mm, OG 19.0 mm	5500	11000
25.0 mm, OG 25.0 mm	7000	11000

Figure 5-4 indicates the approximate weights that may be obtained for various sizes of plates and lift thicknesses that are placed.

Figure 5-5 indicates the approximate weights that may be obtained for various sizes of molds and lift thicknesses when a mold is used with the plate for obtaining a sample.

Approximate Sample Yield for Various Lift Thickness and Plate Sizes								
Lift Thickness (inches)	Lay Rate (lb/syd)	Plate Size, inches						
		8	9	10	11	12	14	16
		Sample Weight (g)						
1.25	137.5	3100	3900	4800	5900	7000	9500	12400
1.5	165	3700	4700	5800	7000	8400	11400	14900
1.75	192.5	4300	5500	6800	8200	9800	13300	17300
2.0	220	5000	6300	7700	9400	11100	15200	19800
2.25	247.5	5600	7100	8700	10500	12500	17100	22300
2.5	275	6200	7800	9700	11700	13900	19000	27800
2.75	302.5	6800	8600	10600	12900	15300	20900	27300
3.0	330	7400	9400	11600	14100	16700	22800	29700
3.25	357.5	8100	10200	12600	15200	18100	24700	32200
3.5	385	8700	11000	13500	16400	19500	26600	34700
3.75	412.5	9300	11800	14500	17600	20900	28500	37200
4.0	440	9900	12500	15500	18700	22300	30300	39600
4.25	467.5	10500	13300	16400	19800	23600	32100	41900
4.5	495	11100	14000	17300	21000	25000	34000	44400
4.75	522.5	11700	14800	18300	22100	26400	35900	46900
5.0	550	12300	15600	19300	23300	27700	37800	49300
5.25	577.5	12900	16400	20200	24500	29100	39700	51800
5.5	605	13600	17200	21200	25600	30500	41500	54300
5.75	632.5	14200	17900	22200	26800	31900	43400	56700
6.0	660	14800	18700	23100	28000	33300	45300	59200

Figure 5-4. Approximate Sample Yield for Various Lift Thickness and Plate Sizes

Approximate Sample Yield for Various Lift Thicknesses and Mold Sizes						
Lift Thickness (inches)	Lay Rate (lb/yd ²)	Mold Size, inches				
		8	10	12	14	16
		Sample Weight (g)				
1.25	137.5	2400	3800	5400	7400	9700
1.5	165	2900	4500	6500	8900	11600
1.75	192.5	3400	5300	7600	10400	13600
2.0	220	3900	6100	8700	11900	15500
2.25	247.5	4400	6800	9800	13300	17400
2.5	275	4800	7600	10900	14800	19400
2.75	302.5	5300	8300	12000	16300	21300
3.0	330	5800	9100	13100	17800	23200
3.25	357.5	6300	9800	14200	19300	25200
3.5	385	6800	10600	15300	20800	27100
3.75	412.5	7300	11300	16300	22200	29100
4.0	440	7700	12100	17400	23700	31000
4.25	467.5	8200	12900	18500	25200	32900
4.5	495	8700	13600	19600	26700	34900
4.75	522.5	9200	14400	20700	28200	36800
5.0	550	9700	15100	21800	29700	38700
5.25	577.5	10200	15900	22900	31100	40700
5.5	605	10700	16600	24000	32600	42600
5.75	632.5	11100	17400	25100	34100	44500
6.0	660	11600	18200	26100	35600	46500

Figure 5-5. Approximate Sample Yield for Various Lift Thicknesses and Mold Sizes

ADJUSTMENT PERIOD -- QC/QA HMA

The Producer is allowed an adjustment period for each mix design in which the mix design is verified and changes may be made in the DMF, if necessary. A job mix formula (JMF) is submitted for approval to the Engineer one working day after the Producer receives the test results for the binder content, VMA, and air content. The adjustment period is from the beginning of production and extending until 5000 t of base or intermediate QC/QA HMA, or 3000 t of surface QC/QA HMA has been produced for each mix design. A reduced adjustment period is allowed. If production extends into the next construction season, another adjustment period is allowed.

MIXTURE ACCEPTANCE

QC/QA HMA

Acceptance of QC/QA HMA mixtures for binder content, VMA at N_{des} , and air voids at N_{des} for each lot is based on tests conducted by INDOT. INDOT randomly selects the location(s) within each subplot for sampling in accordance with the **ITM 802**. Samples from the pavement are obtained from each subplot in accordance with **ITM 580**.

A binder draindown test in accordance with **AASHTO T 305** for open graded mixtures is required once per lot and may not exceed 0.50 %.

The acceptance test results for each subplot are available after the subplot and the testing are complete.

HMA

Acceptance of HMA mixtures is done on the basis of a Type D certification submitted by the Producer to the Project Engineer on a contract. An example of this form is shown in Figure 5-6. The certification is required to be submitted with the first truck of each type of mixture each day. If no test results are available, the Producer indicates on the form that test results are required to be obtained within the first 250 tons and each subsequent 1000 tons for base and intermediate mixtures, and the first 250 tons and each subsequent 600 tons for surface mixtures.

**INDIANA DEPARTMENT OF TRANSPORTATION
HOT MIX ASPHALT (HMA) CERTIFICATION**

CONTRACT NUMBER RS-30000 DATE 5/3/07

CERTIFIED HMA PRODUCER J. Wooden Construction

CERTIFIED HMA PLANT NUMBER 3550 DMF/JMF NUMBER 0310075

PG BINDER SOURCE 7199 PG BINDER GRADE PG 64-22

MIXTURE TYPE AND SIZE HMA Surface, 9.5 mm, Type A

DESIGN ESAL 200,000

Air Voids 4.0 (from DMF/JMF) Binder Content 5.5 (from DMF/JMF)

This is to certify that the test results for Air Voids and Binder Content represent the HMA mixture supplied to this contract.

Air Voids 4.3 (± 1.5 % from DMF/JMF) Binder Content 5.7 (± 0.7 % from DMF/JMF)

* [] Test results are not available for submittal. A production sample shall be taken within the first 250 t (250 Mg) and each subsequent 1000 t (1000 Mg) for base and intermediate mixtures and each subsequent 600 t (600 Mg) for surface mixtures.

* ☒ If Applicable

Signature of HMA Producer Official

Title of Official

FOR PE/PS USE ONLY

PAY ITEM(S) _____ BASIS FOR USE NO. C999998

SPECIFICATION REFERENCE

<input type="checkbox"/> 304.04 - Patching	<input type="checkbox"/> 402.07(c) - Temporary HMA	<input type="checkbox"/> 610.02 - Approaches
<input type="checkbox"/> 304.05 - Widening	<input type="checkbox"/> 503.03(e) - Terminal Joints	<input type="checkbox"/> 611.02 - Crossovers
<input type="checkbox"/> 402.04 - HMA Pavements	<input type="checkbox"/> 507.05(b) - Partial Depth Patching	<input type="checkbox"/> 718.04 - Underdrains
<input type="checkbox"/> 402.07(a) - Rumble Strips	<input type="checkbox"/> 604.07(c) - Sidewalk	<input type="checkbox"/> 801.11 - Temp. Cross
<input type="checkbox"/> 402.07(b) - Wedge & Leveling	<input type="checkbox"/> 605.07(c) - Curbing	

Figure 5-6. HMA Certification

PAY FACTORS – QC/QA HMA (Dense Graded ≥ 1 Lot)

Pay factors for dense graded QC/QA HMA mixtures with original pay item quantities greater than or equal to one lot are determined in accordance with the procedures for Percent Within Limits (PWL) designated in **ITM 588**. The PWL method uses the average and standard deviation of the lot tests to estimate the percentage of the lot that is within the specification limits. The procedure for determining the PWL of the lot is as follows:

PWL - Mixture

1. Determine the average of the lot mixture properties for binder content, air voids at N_{des} , and VMA at N_{des} as follows:

$$\bar{x} = \sum_{i=1}^n \frac{x_i}{n}$$

where:

\bar{x} = average of the lot mixture property values

x_i = subplot mixture property value

n = number of mixture subplot samples in the lot

The binder content, air voids,, and VMA lot average values are reported to the nearest 0.01 %.

2. Determine the standard deviation of the lot mixture property as follows:

$$s = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}}$$

where:

s = standard deviation of the lot mixture property

x_i = subplot mixture property value

\bar{x} = average of the lot mixture property values

n = number of mixture subplot samples in the lot

The standard deviation values for binder content, air voids, and VMA are reported to the nearest 0.01.

3. Calculate the Upper Quality Index for each mixture property by subtracting the lot average of each mixture property from the Upper Specification Limit (Figure 5-7) and dividing the result by the standard deviation of the lot mixture property as follows:

$$Q_U = \frac{USL - \bar{x}}{s}$$

where:

Q_u = Upper Quality Index

USL = Upper Specification Limit

\bar{x} = average of the lot mixture property values

s = standard deviation of the lot mixture property

The binder content, air voids, and VMA Upper Quality Index values are reported to the nearest 0.01

SPECIFICATION LIMITS				
Mixture				
	LSL*		USL**	
Binder Content, %	- 0.40 from JMF		+ 0.40 from JMF	
Air Voids(Va) at N _{des} , %	2.60		5.40	
VMA at N _{des} , %	Greater Of		Lesser Of	
	Spec-0.50	JMF-1.20	Spec+2.00	JMF+1.20
Density				
	LSL		USL	
Roadway Core Density (%Gmm), %	91.00		Not Applicable	
* LSL, Lower Specification Limit				
** USL, Upper Specification Limit				

Figure 5-7. Specification Limits

4. Calculate the Lower Quality Index for each mixture property by subtracting the Lower Specification Limit (Figure 5-7) from the lot average of each mixture property and dividing the result by the standard deviation of the lot mixture property as follows:

$$Q_L = \frac{\bar{x} - LSL}{s}$$

where:

Q_L = Lower Quality Index

LSL = Lower Specification Limit

\bar{x} = average of the lot mixture property values

s = standard deviation of the lot mixture property

The binder content, air voids, and VMA Lower Quality Index values are reported to the nearest 0.01

5. Determine the percentage of material that will fall within the Upper and Lower Specification Limits (Figure 5-7) by entering the table of Quality Index Values (Figure 5-8) with Q_U or Q_L using the column appropriate to the total number of measurements, n .
6. Determine the percent of material that will fall within the limits for each mixture property by adding the percent within the Upper Specification Limit (PWL_U) to the percent within the Lower Specification Limit (PWL_L), and subtracting 100 from the total as follows:

$$\text{Total PWL} = (PWL_U + PWL_L) - 100$$

PWL - Density

1. Determine the average of the lot density values as follows:

$$\bar{x} = \sum_{i=1}^n \frac{x_i}{n}$$

where:

\bar{x} = average of the lot density values

x_i = core density value

n = number of cores in the lot

The density (% Gmm) lot average value is reported to the nearest 0.01 %.

2. Determine the standard deviation of the lot density as follows:

$$s = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}}$$

where:

s = standard deviation of the density of the lot

\bar{x} = average of the lot density values

x_i = core density value

n = number of cores in the lot

The standard deviation value is reported to the nearest 0.01.

3. Calculate the Lower Quality Index for in-place density (% G_{mm}) by subtracting the Lower Specification Limit (Figure 5-7) from the average of the density of the lot and dividing the result by the standard deviation of the density of the lot as follows:

$$Q_L = \frac{\bar{x} - LSL}{s}$$

where:

Q_L = Lower Quality Index

LSL = Lower Specification Limit

\bar{x} = average of the lot density values

s = standard deviation of the density of the lot

The density Lower Quality Index value is reported to the nearest 0.01.

4. Determine the PWL for density by entering the table of Quality Index Values (Figure 5-8) using the column appropriate to the total number of measurements, n .
5. Determine the percent within the lower specification limit (PWL_L) for density as follows:

$$\text{Total PWL} = PWL_L$$

Quality Index (QI) Values PWL for a given sample size (n)												
QI	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	n=11	n=12	n=13	n=14
2.30	100	100	100	100	100	100	100	100	100	100	100	100
2.29	100	100	100	100	100	100	100	100	100	100	100	99
2.28	100	100	100	100	100	100	100	100	100	100	100	99
2.27	100	100	100	100	100	100	100	100	100	100	99	99
2.26	100	100	100	100	100	100	100	100	100	100	99	99
2.25	100	100	100	100	100	100	100	100	100	100	99	99
2.24	100	100	100	100	100	100	100	100	100	99	99	99
2.23	100	100	100	100	100	100	100	100	100	99	99	99
2.22	100	100	100	100	100	100	100	100	100	99	99	99
2.21	100	100	100	100	100	100	100	100	99	99	99	99
2.20	100	100	100	100	100	100	100	100	99	99	99	99
2.19	100	100	100	100	100	100	100	100	99	99	99	99
2.18	100	100	100	100	100	100	100	100	99	99	99	99
2.17	100	100	100	100	100	100	100	99	99	99	99	99
2.16	100	100	100	100	100	100	100	99	99	99	99	99
2.15	100	100	100	100	100	100	100	99	99	99	99	99
2.14	100	100	100	100	100	100	100	99	99	99	99	99
2.13	100	100	100	100	100	100	100	99	99	99	99	99
2.12	100	100	100	100	100	100	99	99	99	99	99	99
2.11	100	100	100	100	100	100	99	99	99	99	99	99
2.10	100	100	100	100	100	100	99	99	99	99	99	99
2.09	100	100	100	100	100	100	99	99	99	99	99	99
2.08	100	100	100	100	100	100	99	99	99	99	99	99
2.07	100	100	100	100	100	100	99	99	99	99	99	99
2.06	100	100	100	100	100	99	99	99	99	99	99	99
2.05	100	100	100	100	100	99	99	99	99	99	99	99
2.04	100	100	100	100	100	99	99	99	99	99	99	99
2.03	100	100	100	100	100	99	99	99	99	99	99	99
2.02	100	100	100	100	100	99	99	99	99	99	99	99
2.01	100	100	100	100	100	99	99	99	99	99	99	98
2.00	100	100	100	100	100	99	99	99	99	99	99	98
1.99	100	100	100	100	100	99	99	99	99	99	98	98
1.98	100	100	100	100	99	99	99	99	99	98	98	98
1.97	100	100	100	100	99	99	99	99	99	98	98	98
1.96	100	100	100	100	99	99	99	99	98	98	98	98
1.95	100	100	100	100	99	99	99	99	98	98	98	98
1.94	100	100	100	100	99	99	99	99	98	98	98	98
1.93	100	100	100	100	99	99	99	98	98	98	98	98

Figure 5-8. Quality Index (QI) Values

Quality Index (QI) Values PWL for a given sample size (n)												
1.92	100	100	100	100	99	99	99	98	98	98	98	98
1.91	100	100	100	100	99	99	99	98	98	98	98	98
1.90	100	100	100	100	99	99	98	98	98	98	98	98
1.89	100	100	100	100	99	99	98	98	98	98	98	98
1.88	100	100	100	100	99	99	98	98	98	98	98	98
1.87	100	100	100	99	99	98	98	98	98	98	98	98
1.86	100	100	100	99	99	98	98	98	98	98	98	98
1.85	100	100	100	99	99	98	98	98	98	98	98	98
1.84	100	100	100	99	99	98	98	98	98	98	97	97
1.83	100	100	100	99	99	98	98	98	98	98	97	97
1.82	100	100	100	99	99	98	98	98	98	97	97	97
1.81	100	100	100	99	98	98	98	98	97	97	97	97
1.80	100	100	100	99	98	98	98	98	97	97	97	97
1.79	100	100	100	99	98	98	98	97	97	97	97	97
1.78	100	100	100	99	98	98	98	97	97	97	97	97
1.77	100	100	100	99	98	98	97	97	97	97	97	97
1.76	100	100	100	99	98	98	97	97	97	97	97	97
1.75	100	100	100	99	98	98	97	97	97	97	97	97
1.74	100	100	100	98	98	97	97	97	97	97	97	97
1.73	100	100	100	98	98	97	97	97	97	97	97	97
1.72	100	100	100	98	98	97	97	97	97	97	96	96
1.71	100	100	99	98	97	97	97	97	97	96	96	96
1.70	100	100	99	98	97	97	97	97	96	96	96	96
1.69	100	100	99	98	97	97	97	96	96	96	96	96
1.68	100	100	99	98	97	97	97	96	96	96	96	96
1.67	100	100	99	98	97	97	96	96	96	96	96	96
1.66	100	100	99	98	97	97	96	96	96	96	96	96
1.65	100	100	99	97	97	96	96	96	96	96	96	96
1.64	100	100	99	97	97	96	96	96	96	96	96	96
1.63	100	100	98	97	97	96	96	96	96	96	96	95
1.62	100	100	98	97	96	96	96	96	96	95	95	95
1.61	100	100	98	97	96	96	96	96	95	95	95	95
1.60	100	100	98	97	96	96	96	95	95	95	95	95
1.59	100	100	98	97	96	96	95	95	95	95	95	95
1.58	100	100	98	96	96	96	95	95	95	95	95	95
1.57	100	100	97	96	96	95	95	95	95	95	95	95
1.56	100	100	97	96	96	95	95	95	95	95	95	95
1.55	100	100	97	96	95	95	95	95	95	95	95	95

Quality Index Values (continued)

Quality Index (QI) Values PWL for a given sample size (n)												
QI	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	n=11	n=12	n=13	n=14
1.54	100	100	97	96	95	95	95	95	95	94	94	94
1.53	100	100	97	96	95	95	95	95	94	94	94	94
1.52	100	100	97	96	95	95	95	94	94	94	94	94
1.51	100	100	96	95	95	95	94	94	94	94	94	94
1.50	100	100	96	95	95	94	94	94	94	94	94	94
1.49	100	100	96	95	95	94	94	94	94	94	94	94
1.48	100	99	96	95	94	94	94	94	94	94	94	94
1.47	100	99	96	95	94	94	94	94	94	94	93	93
1.46	100	99	95	94	94	94	94	94	93	93	93	93
1.45	100	98	95	94	94	94	93	93	93	93	93	93
1.44	100	98	95	94	94	93	93	93	93	93	93	93
1.43	100	98	95	94	94	93	93	93	93	93	93	93
1.42	100	97	95	94	93	93	93	93	93	93	93	93
1.41	100	97	94	94	93	93	93	93	93	93	93	93
1.40	100	97	94	93	93	93	93	93	92	92	92	92
1.39	100	96	94	93	93	93	92	92	92	92	92	92
1.38	100	96	94	93	93	92	92	92	92	92	92	92
1.37	100	96	93	93	92	92	92	92	92	92	92	92
1.36	100	95	93	93	92	92	92	92	92	92	92	92
1.35	100	95	93	92	92	92	92	92	92	92	92	92
1.34	100	95	93	92	92	92	92	92	91	91	91	91
1.33	100	94	93	92	92	92	91	91	91	91	91	91
1.32	100	94	92	92	91	91	91	91	91	91	91	91
1.31	100	94	92	92	91	91	91	91	91	91	91	91
1.30	100	93	92	91	91	91	91	91	91	91	91	91
1.29	100	93	92	91	91	91	91	91	91	90	90	90
1.28	100	93	91	91	91	91	90	90	90	90	90	90
1.27	100	92	91	91	90	90	90	90	90	90	90	90
1.26	100	92	91	90	90	90	90	90	90	90	90	90
1.25	100	92	91	90	90	90	90	90	90	90	90	90
1.24	100	91	90	90	90	90	90	90	90	90	90	89
1.23	100	91	90	90	90	89	89	89	89	89	89	89
1.22	100	91	90	89	89	89	89	89	89	89	89	89
1.21	100	90	90	89	89	89	89	89	89	89	89	89
1.20	100	90	89	89	89	89	89	89	89	89	89	89
1.19	100	90	89	89	89	89	89	89	89	88	88	88
1.18	100	89	89	89	88	88	88	88	88	88	88	88
1.17	100	89	88	88	88	88	88	88	88	88	88	88

Quality Index Values (continued)

Quality Index (QI) Values PWL for a given sample size (n)												
QI	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	n=11	n=12	n=13	n=14
1.16	100	89	88	88	88	88	88	88	88	88	88	88
1.15	97	88	88	88	88	88	88	88	88	88	88	88
1.14	95	88	88	88	87	87	87	87	87	87	87	87
1.13	93	88	87	87	87	87	87	87	87	87	87	87
1.12	92	87	87	87	87	87	87	87	87	87	87	87
1.11	91	87	87	87	87	87	87	87	87	87	87	87
1.10	90	87	87	87	87	87	87	87	87	87	86	86
1.09	89	86	86	86	86	86	86	86	86	86	86	86
1.08	88	86	86	86	86	86	86	86	86	86	86	86
1.07	88	86	86	86	86	86	86	86	86	86	86	86
1.06	87	85	85	85	85	86	86	86	86	86	86	86
1.05	86	85	85	85	85	85	85	85	85	85	85	85
1.04	86	85	85	85	85	85	85	85	85	85	85	85
1.03	85	84	85	85	85	85	85	85	85	85	85	85
1.02	84	84	84	84	84	84	85	85	85	85	85	85
1.01	84	84	84	84	84	84	84	84	84	84	84	84
1.00	83	83	84	84	84	84	84	84	84	84	84	84
0.99	83	83	83	84	84	84	84	84	84	84	84	84
0.98	82	83	83	83	83	83	83	84	84	84	84	84
0.97	82	82	83	83	83	83	83	83	83	83	83	83
0.96	81	82	82	83	83	83	83	83	83	83	83	83
0.95	81	82	82	82	83	83	83	83	83	83	83	83
0.94	80	81	82	82	82	82	82	82	82	82	83	83
0.93	80	81	82	82	82	82	82	82	82	82	82	82
0.92	79	81	81	82	82	82	82	82	82	82	82	82
0.91	79	80	81	81	81	81	82	82	82	82	82	82
0.90	78	80	81	81	81	81	81	81	81	81	81	81
0.89	78	80	80	81	81	81	81	81	81	81	81	81
0.88	78	79	80	80	81	81	81	81	81	81	81	81
0.87	77	79	80	80	80	80	80	80	81	81	81	81
0.86	77	79	79	80	80	80	80	80	80	80	80	80
0.85	76	78	79	79	80	80	80	80	80	80	80	80
0.84	76	78	79	79	79	79	80	80	80	80	80	80
0.83	76	78	78	79	79	79	79	79	79	79	79	79
0.82	75	77	78	79	79	79	79	79	79	79	79	79
0.81	75	77	78	78	78	79	79	79	79	79	79	79
0.80	74	77	77	78	78	78	78	78	78	79	79	79
0.79	74	76	77	78	78	78	78	78	78	78	78	78
0.78	74	76	77	77	77	78	78	78	78	78	78	78
0.77	73	76	77	77	77	77	77	78	78	78	78	78
0.76	73	75	76	77	77	77	77	77	77	77	77	77

Quality Index Values (continued)

Quality Index (QI) Values PWL for a given sample size (n)												
QI	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	n=11	n=12	n=13	n=14
0.75	73	75	76	76	77	77	77	77	77	77	77	77
0.74	72	75	76	76	76	76	77	77	77	77	77	77
0.73	72	74	75	76	76	76	76	76	76	76	76	76
0.72	71	74	75	75	76	76	76	76	76	76	76	76
0.71	71	74	75	75	75	75	76	76	76	76	76	76
0.70	71	73	74	75	75	75	75	75	75	75	75	76
0.69	70	73	74	74	75	75	75	75	75	75	75	75
0.68	70	73	74	74	74	74	75	75	75	75	75	75
0.67	70	72	73	74	74	74	74	74	74	74	75	75
0.66	69	72	73	73	74	74	74	74	74	74	74	74
0.65	69	72	73	73	73	74	74	74	74	74	74	74
0.64	69	71	72	73	73	73	73	73	73	74	74	74
0.63	68	71	72	72	73	73	73	73	73	73	73	73
0.62	68	71	72	72	72	73	73	73	73	73	73	73
0.61	68	70	71	72	72	72	72	72	72	73	73	73
0.60	67	70	71	71	72	72	72	72	72	72	72	72
0.59	67	70	71	71	71	72	72	72	72	72	72	72
0.58	67	69	70	71	71	71	71	71	71	72	72	72
0.57	66	69	70	70	71	71	71	71	71	71	71	71
0.56	66	69	70	70	70	71	71	71	71	71	71	71
0.55	66	68	69	70	70	70	70	70	70	70	71	71
0.54	65	68	69	69	70	70	70	70	70	70	70	70
0.53	65	68	69	69	69	69	70	70	70	70	70	70
0.52	65	67	68	69	69	69	69	69	69	69	69	70
0.51	65	67	68	68	69	69	69	69	69	69	69	69
0.50	64	67	68	68	68	68	69	69	69	69	69	69
0.49	64	66	67	68	68	68	68	68	68	68	68	68
0.48	64	66	67	67	68	68	68	68	68	68	68	68
0.47	63	66	67	67	67	67	67	68	68	68	68	68
0.46	63	65	66	67	67	67	67	67	67	67	67	67
0.45	63	65	66	66	67	67	67	67	67	67	67	67
0.44	62	65	65	66	66	66	66	67	67	67	67	67
0.43	62	64	65	66	66	66	66	66	66	66	66	66
0.42	62	64	65	65	65	66	66	66	66	66	66	66
0.41	62	64	64	65	65	65	65	65	65	66	66	66
0.40	61	63	64	65	65	65	65	65	65	65	65	65
0.39	61	63	64	64	64	65	65	65	65	65	65	65
0.38	61	63	63	64	64	64	64	64	64	64	64	65

Quality Index Values (continued)

Quality Index (QI) Values PWL for a given sample size (n)												
QI	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	n=11	n=12	n=13	n=14
0.37	60	62	63	63	64	64	64	64	64	64	64	64
0.36	60	62	63	63	63	63	64	64	64	64	64	64
0.35	60	62	62	63	63	63	63	63	63	63	63	63
0.34	60	61	62	62	63	63	63	63	63	63	63	63
0.33	59	61	62	62	62	62	62	63	63	63	63	63
0.32	59	61	61	62	62	62	62	62	62	62	62	62
0.31	59	60	61	61	61	62	62	62	62	62	62	62
0.30	58	60	61	61	61	61	61	61	61	61	62	62
0.29	58	60	60	61	61	61	61	61	61	61	61	61
0.28	58	59	60	60	60	61	61	61	61	61	61	61
0.27	58	59	60	60	60	60	60	60	60	60	60	60
0.26	57	59	59	60	60	60	60	60	60	60	60	60
0.25	57	58	59	59	59	59	59	60	60	60	60	60
0.16	54	55	56	56	56	56	56	56	56	56	56	56
0.15	54	55	55	56	56	56	56	56	56	56	56	56
0.14	54	55	55	55	55	55	55	55	55	55	55	55
0.13	54	54	55	55	55	55	55	55	55	55	55	55
0.12	53	54	54	54	54	55	55	55	55	55	55	55
0.11	53	54	54	54	54	54	54	54	54	54	54	54
0.10	53	53	54	54	54	54	54	54	54	54	54	54
0.09	52	53	53	53	53	53	53	53	53	53	53	54
0.08	52	53	53	53	53	53	53	53	53	53	53	53
0.07	52	52	52	53	53	53	53	53	53	53	53	53
0.06	52	52	52	52	52	52	52	52	52	52	52	52
0.05	51	52	52	52	52	52	52	52	52	52	52	52
0.04	51	51	51	51	51	52	52	52	52	52	52	52
0.03	51	51	51	51	51	51	51	51	51	51	51	51
0.02	51	51	51	51	51	51	51	51	51	51	51	51
0.01	50	50	50	50	50	50	50	50	50	50	50	50
0.00	50	50	50	50	50	50	50	50	50	50	50	50
-0.01	50	50	50	50	50	50	50	50	50	50	50	50
-0.02	49	49	49	49	49	49	49	49	49	49	49	49
-0.03	49	49	49	49	49	49	49	49	49	49	49	49
-0.04	49	49	49	49	49	48	48	48	48	48	48	48
-0.05	49	48	48	48	48	48	48	48	48	48	48	48
-0.06	48	48	48	48	48	48	48	48	48	48	48	48
-0.07	48	48	48	47	47	47	47	47	47	47	47	47
-0.08	48	47	47	47	47	47	47	47	47	47	47	47
-0.09	48	47	47	47	47	47	47	47	47	47	47	46
-0.10	47	47	46	46	46	46	46	46	46	46	46	46

Quality Index Values (continued)

Quality Index (QI) Values PWL for a given sample size (n)												
QI	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	n=11	n=12	n=13	n=14
-0.11	47	46	46	46	46	46	46	46	46	46	46	46
-0.12	47	46	46	46	46	45	45	45	45	45	45	45
-0.13	46	46	45	45	45	45	45	45	45	45	45	45
-0.14	46	45	45	45	45	45	45	45	45	45	45	45
-0.15	46	45	45	44	44	44	44	44	44	44	44	44
-0.16	46	45	44	44	44	44	44	44	44	44	44	44
-0.17	45	44	44	44	44	44	44	43	43	43	43	43
-0.18	45	44	44	43	43	43	43	43	43	43	43	43
-0.19	45	44	43	43	43	43	43	43	43	43	43	43
-0.20	44	43	43	43	43	42	42	42	42	42	42	42
-0.21	44	43	43	42	42	42	42	42	42	42	42	42
-0.22	44	43	42	42	42	42	42	42	42	42	42	
-0.23	44	42	42	42								
-0.24	43	42										
-0.25	43	42										
-0.26	43											
-0.27	42											
-0.28	42											
-0.29	42											
-0.30	42											

Quality Index Values (continued)

Pay Factors

Pay factors (PF) are calculated for the binder content, air voids at N_{des} , VMA at N_{des} , and in-place density (% Gmm). The appropriate pay factor for each property is calculated as follows:

Estimated PWL > 90

$$\text{Pay Factor} = (105.00 - 0.50 \times (100.00 - \text{PWL})/100$$

Estimated PWL ≥ 50 and ≤ 90

$$\text{Pay Factor} = (100.00 - 0.000020072 \times (100.00 - \text{PWL})^{3.5877})/100$$

Binder content, air voids, VMA, and in-place density PF values are reported to the nearest 0.01.

If the Lot PWL for any one of the properties is less than 50 or a subplot has an air void content less than 1.0 %, the lot is referred to the Office of Materials Management as a failed material.

A composite pay factor for each lot based on the mixture properties and density is determined by a weighted formula as follows:

$$\begin{aligned} \text{Lot Pay Factor} = & 0.20 (\text{PF}_{\text{BINDER}}) + 0.35 (\text{PF}_{\text{VOIDS}}) + 0.10 (\text{PF}_{\text{VMA}}) \\ & + 0.35 (\text{PF}_{\text{DENSITY}}) \end{aligned}$$

where:

- Lot PF = Lot Composite Pay Factor for Mixture and Density
- $\text{PF}_{\text{BINDER}}$ = Lot Pay Factor for Binder Content
- PF_{VOIDS} = Lot Pay Factor for Air Vois at N_{des}
- PF_{VMA} = Lot Pay Factor for VMA at N_{des}
- $\text{PF}_{\text{DENSITY}}$ = Lot Pay Factor for In-Place Density (%Gmm)

ADJUSTMENT QUANTITY -- QC/QA HMA ≥ 1 Lot

The pay factors are used to calculate a quality assurance adjustment quantity (q) for the lot. The adjustment for mixture properties and density is calculated as follows:

$$q = L \times U \times (\text{Lot PF} - 1.00)/\text{MAF}$$

where:

- q = quality assurance adjustment for mixture properties and density of the lot
- L = Lot quantity
- U = Unit price for the material, \$/Ton
- Lot PF = Lot Pay Factor

The following example indicates how the Pay Factors and the Quality Assurance Adjustment for PWL are determined for QC/QA mixtures ≥ 1 Lot:

Example:

19.0 mm Intermediate

Sublot 1 = 1000 tons

Sublot 2 = 1000 tons

Sublot 3 = 1000 tons

Sublot 4 = 1000 tons

Sublot 5 = 1000 tons

Unit Price = \$40.00/ton

MAF = 1.000

JMF % Binder = 5.0 %
 Air Voids = 4.0 %
 VMA = 13.5 %

	Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5
% Binder	4.80	4.90	5.20	5.20	5.30
Air Voids	3.80	3.50	3.20	4.70	4.60
VMA	13.80	13.90	12.60	12.80	13.70
Density (%MSG)	91.10	91.70	92.30	92.90	92.50

% Binder

$$\bar{x} = \frac{4.80 + 4.90 + 5.20 + 5.20 + 5.30}{5} = 5.08$$

$$s = 0.22$$

$$USL = + 0.40 \text{ from JMF} = 0.40 + 5.0 = 5.40$$

$$Q_U = \frac{USL - \bar{x}}{s} = \frac{5.40 - 5.08}{0.22} = 1.45$$

From Figure 5-8 for n = 5 the PWL_U is 95

$$LSL = -0.40 \text{ from JMF} = 5.0 - 0.40 = 4.60$$

$$Q_L = \frac{\bar{x} - LSL}{s} = \frac{5.08 - 4.60}{0.22} = 2.18$$

From Figure 5-8 for $n = 5$ the PWL_L is 100

$$\text{Total PWL} = (PWL_U + PWL_L) - 100 = (95 + 100) - 100 = 95$$

$$\begin{aligned} \text{Pay Factor (Estimated PWL} > 90) &= (105.00 - 0.50 \times (100.00 - \text{PWL})/100 \\ &= (105.00 - 0.50 \times (100.00 - 95))/100 \\ &= (105.00 - 2.50)/100 = 1.03 \end{aligned}$$

Pay Factors for the Air Voids, VMA, and Density are indicated in Figure 5-9 and are as follows:

$$\text{Pay Factor (Air Voids)} = 1.05$$

$$\text{Pay Factor (VMA)} = 1.02$$

$$\text{Pay Factor (Density)} = 1.04$$

$$\begin{aligned} \text{Lot Pay Factor} &= 0.20 (PF_{\text{BINDER}}) + 0.35 (PF_{\text{VOIDS}}) + 0.10 (PF_{\text{VMA}}) + 0.35 (PF_{\text{DENSITY}}) \\ &= 0.20 (1.03) + 0.35 (1.05) + 0.10 (1.02) + 0.35 (1.04) \\ &= 0.21 + 0.37 + 0.10 + 0.36 = 1.04 \end{aligned}$$

The Quality Assurance Adjustment for the Lot is calculated as follows:

$$\text{Quality Assurance Adjustment (\$)} = L \times U \times (\text{Lot PF} - 1.00)/MAF$$

L = Lot quantity

U = Unit Price for Material, \$/Ton

Lot PF = Lot Pay Factor

$$\begin{aligned} \text{Quality Assurance Adjustment} &= 5000 \times \$40.00 \times (1.04 - 1.00)/1.000 \\ &= + \$8000.00 \end{aligned}$$

**INDIANA DEPARTMENT OF TRANSPORTATION
HOT MIX ASPHALT ANALYSIS FOR QUALITY ASSURANCE**

CONTRACT NO. _____ **PLANT NO.** _____ **LOT NO.** _____ **DATE** _____

MIXTURE _____ **DMF/JMF NO.** _____

Mixture & Density	\bar{x}	s	Qu			QL			Total PWL
			USL	$Q_U = \frac{USL - \bar{x}}{s}$	PWL _U	LSL	$Q_L = \frac{\bar{x} - LSL}{s}$	PWL _L	
% Binder	5.08	0.22	5.40	1.45	95	4.60	2.18	100	95
Air Voids	3.96	0.67	5.40	2.15	100	2.60	2.03	100	100
VMA	13.36	0.61	14.70	2.20	100	12.50	1.41	94	94
Density (% MSG)	92.10	0.71				91.00	1.55	97	97

* Requires submittal to the Office of Materials Management for Failed Material Investigation

Binder		Air Voids		VMA		Density		Lot Pay Factor	Quality Assurance Adjustment
Pay Factor	0.20xPF	Pay Factor	0.35xPF	Pay Factor	0.10xPF	Pay Factor	0.35xPF		
1.03	0.21	1.05	0.37	1.02	0.10	1.04	0.36	1.04	+ \$8000

Estimated PWL > 90

$$\text{Pay Factor} = (105.00 - 0.50 \times (100.00 - \text{PWL})/100$$

Estimated PWL ≥ 50 and ≤ 90

$$\text{Pay Factor} = (100.00 - 0.000020072 \times (100.00 - \text{PWL})^{3.5877})/100$$

$$\text{Lot Pay Factor} = 0.20 (\text{PF}_{\text{BINDER}}) + 0.35 (\text{PF}_{\text{VOIDS}}) + 0.10 (\text{PF}_{\text{VMA}}) + 0.35 (\text{PF}_{\text{DENSITY}})$$

$$\text{Quality Assurance Adjustment (\$)} = L \times U \times (\text{Lot PF} - 1.00)/\text{MAF}$$

L = Lot quantity

U = Unit Price for Material, \$/Ton

Lot PF = Lot Pay Factor

Figure 5-9. Quality Assurance Adjustment

PAY FACTORS -- QC/QA HMA (Dense Graded Mixture < 1 Lot and Open Graded Mixtures)

After the tests are conducted, the test data is evaluated for compliance with the Specifications. CAA and temperature tests are taken in accordance with standard procedures and recorded. For open graded mixtures, lot numbers begin with number 1 for each type of mixture and are continuous for the entire contract regardless of the number of adjustment periods for that type of mixture. Mixtures with original pay item quantities less than 300 tons will be accepted by Type D Certification.

When the required tests for one subplot are completed, the difference between the test values and the required value on the JMF is determined and pay factors calculated. For mixtures produced during the adjustment period, pay factors based on the JMF are used. A composite pay factor for each subplot is determined for the binder content, air voids @ N_{des} , VMA @ N_{des} , and density of the mixture as follows:

$$SCPF = 0.20(PF_{BINDER}) + 0.35(PF_{VOIDS}) + 0.10(PF_{VMA}) + 0.35(PF_{DENSITY})$$

where:

SCPF	=	Sublot Composite Pay Factor for Mixture and Density
PF_{BINDER}	=	Sublot Pay Factor for Binder Content
PF_{VOIDS}	=	Sublot Pay Factor for Air Voids at N_{des}
PF_{VMA}	=	Sublot Pay Factor for VMA at N_{des}
$PF_{DENSITY}$	=	Sublot Pay Factor for Density

If the SCPF for a subplot is less than 0.85, the pavement is evaluated by INDOT. If the Contractor is not required to remove the mixture, quality assurance adjustments of the subplot are assessed or other corrective actions taken as determined by INDOT.

MIXTURE

Sublot test results for mixture properties are assigned pay factors in accordance with the following:

BINDER CONTENT		
DENSE GRADED Deviation from JMF (±%)	OPEN GRADED Deviation from JMF (±%)	PAY FACTOR
≤ 0.2	≤ 0.2	1.05
0.3	0.3	1.04
0.4	0.4	1.02
0.5	0.5	1.00
0.6	0.6	0.90
0.7	0.7	0.80
0.8	0.8	0.60
0.9	0.9	0.30
1.0	1.0	0.00
> 1.0	> 1.0	Submit to the Office of Materials Management*

* Test results are considered and adjudicated as a failed material in accordance with normal INDOT practice as listed in 105.03.

AIR VOIDS		
DENSE GRADED Deviation from JMF (±%)	OPEN GRADED Deviation from JMF (±%)	PAY FACTOR
≤ 0.5	≤ 1.0	1.05
> 0.5 and ≤ 1.0	> 1.0 and ≤ 3.0	1.00
1.1	3.1	0.98
1.2	3.2	0.96
1.3	3.3	0.94
1.4	3.4	0.92
1.5	3.5	0.90
1.6	3.6	0.84
1.7	3.7	0.78
1.8	3.8	0.72
1.9	3.9	0.66
2.0	4.0	0.60
> 2.0	> 4.0	Submit to the Office of Materials Management*

* Test results are considered and adjudicated as a failed material in accordance with normal INDOT practice as listed in 105.03.

VMA		
DENSE GRADED Deviation from JMF (±%)	OPEN GRADED Deviation from JMF (±%)	PAY FACTOR
≤ 0.5		1.05
> 0.5 and ≤ 1.0	All	1.00
> 1.0 and ≤ 1.5		0.90
> 1.5 and ≤ 2.0		0.70
> 2.0 and ≤ 2.5		0.30
> 2.5		Submit to the Office of Materials Management*

* Test results are considered and adjudicated as a failed material in accordance with normal INDOT practice as listed in 105.03.

DENSITY

Sublot test results for density are assigned pay factors in accordance with the following:

DENSITY		
Percentages based on % MSG	Pay Factors – Percent	
Dense Graded	Open Graded	
≥ 97.0		Submitted to the Office of Materials Management*
95.6 - 96.9		1.05 - 0.01 for each 0.1% above 95.5
94.0 - 95.5		1.05
93.1 - 93.9		1.00 + 0.005 for each 0.1% above 93.0
92.0 - 93.0	84.0	1.00
91.0 - 91.9		1.00 - 0.005 for each 0.1% below 92.0
90.0 - 90.9		0.95 - 0.010 for each 0.1% below 91.0
89.0 - 89.9		0.85 - 0.030 for each 0.1% below 90.0
≤ 88.9		Submitted to the Office of Materials Management*

* Test results are considered and adjudicated as a failed material in accordance with normal INDOT practice as listed in 105.03.

Figure 5-10 indicates the density pay factors required for the % Maximum Specific Gravity of the cores.

DENSITY -- DENSE GRADED							
% MSG	Pay Factor	% MSG	Pay Factor	% MSG	Pay Factor	% MSG	Pay Factor
≥97.0	*	94.9	1.05	92.8	1.00	90.7	0.92
96.9	0.91	94.8	1.05	92.7	1.00	90.6	0.91
96.8	0.92	94.7	1.05	92.6	1.00	90.5	0.90
96.7	0.93	94.6	1.05	92.5	1.00	90.4	0.89
96.6	0.94	94.5	1.05	92.4	1.00	90.3	0.88
96.5	0.95	94.4	1.05	92.3	1.00	90.2	0.87
96.4	0.96	94.3	1.05	92.2	1.00	90.1	0.86
96.3	0.97	94.2	1.05	92.1	1.00	90.0	0.85
96.2	0.98	94.1	1.05	92.0	1.00	89.9	0.82
96.1	0.99	94.0	1.05	91.9	1.00	89.8	0.79
96.0	1.00	93.9	1.05	91.8	0.99	89.7	0.76
95.9	1.01	93.8	1.04	91.7	0.99	89.6	0.73
95.8	1.02	93.7	1.04	91.6	0.98	89.5	0.70
95.7	1.03	93.6	1.03	91.5	0.98	89.4	0.67
95.6	1.04	93.5	1.03	91.4	0.97	89.3	0.64
95.5	1.05	93.4	1.02	91.3	0.97	89.2	0.61
95.4	1.05	93.3	1.02	91.2	0.96	89.1	0.58
95.3	1.05	93.2	1.01	91.1	0.96	89.0	0.55
95.2	1.05	93.1	1.01	91.0	0.95	88.9	*
95.1	1.05	93.0	1.00	90.9	0.94		
95.0	1.05	92.9	1.00	90.8	0.93		
DENSITY -- OPEN GRADED							
84.0 -- 1.00							

* Requires submittal to Office of Materials Management for Failed Material Investigation

Figure 5-10. Density Pay Factors

ADJUSTMENT QUANTITY -- QC/QA HMA < 1 Lot and Open Graded Mixtures

The pay factors are used to calculate a quality assurance adjustment quantity (q) for the subplot. The adjustment for mixture properties and density is calculated as follows:

$$q = L \times U \times (SCPF - 1.00)/MAF$$

where:

- q = quality assurance adjustment for the subplot
- L = Sublot quantity
- U = Unit price for the material, \$/Ton
- SCPF = Sublot composite pay factor

The following example indicates how Quality Assurance Adjustments are determined for QC/QA mixtures < 1 Lot and Open Graded mixtures:

Example:

25.0 mm Base

Sublot 1 = 1000 tons

Sublot 2 = 1000 tons

Sublot 3 = 1000 tons

Sublot 4 = 1000 tons

Unit Price = \$28.00/ton

MAF = 1.000

JMF % Binder = 4.2 %
 Air Voids = 4.0 %
 VMA = 12.5 %

	Sublot 1	Sublot 2	Sublot 3	Sublot 4
% Binder	4.5	4.6	4.8	4.2
Air Voids	3.8	3.7	3.2	4.7
VMA	12.2	12.1	11.6	13.4
Density (%MSG)	91.1	90.7	89.9	92.9

Deviations for JMF % Binder, Air Voids, and VMA:

	Sublot 1	Sublot 2	Sublot 3	Sublot 4
% Binder	0.3	0.4	0.6	0.2
Air Voids	0.2	0.3	0.8	0.7
VMA	0.3	0.4	0.9	0.9

Using the pay factor charts, the following values are obtained:

	Sublot 1	Sublot 2	Sublot 3	Sublot 4
% Binder	1.04	1.02	0.90	1.05
Air Voids	1.05	1.05	1.00	1.00
VMA	1.05	1.05	1.00	1.00
Density (%MSG)	0.96	0.92	0.82	1.00

Calculations to determine the Quality Assurance Adjustment are indicated in Figure 5-11.

**INDIANA DEPARTMENT OF TRANSPORTATION
HOT MIX ASPHALT ANALYSIS FOR QUALITY ASSURANCE**

CONTRACT NO. _____ **PLANT NO.** _____ **LOT NO.** _____ **DATE** _____

MIXTURE _____ **DMF/JMF NO.** _____

Mixture & Density	SUBLOT 1			SUBLOT 2			SUBLOT 3			SUBLOT 4		
	Pay Factor	Mult		Pay Factor	Mult		Pay Factor	Mult.		Pay Factor	Mult.	
% Binder	1.04	0.20	0.2080	1.02	0.20	0.2040	0.90	0.20	0.1800	1.05	0.20	0.2100
Air Voids	1.05	0.35	0.3675	1.05	0.35	0.3675	1.00	0.35	0.3500	1.00	0.35	0.3500
VMA	1.05	0.10	0.1050	1.05	0.10	0.1050	1.00	0.10	0.1000	1.00	0.10	0.1000
Density	0.96	0.35	0.3360	0.92	0.35	0.3220	0.82	0.35	0.2870	1.00	0.35	0.3500
SCPF			1.02			1.00			0.92			1.01

* Requires submittal to the Materials and Tests Division for Failed Material Investigation

QUALITY ASSURANCE ADJUSTMENTS							
Sublot 1 Quantity L (tons)	Sublot 1 Adjustment (\$)	Sublot 2 Quantity L (tons)	Sublot 2 Adjustment (\$)	Sublot 3 Quantity L (tons)	Sublot 3 Adjustment (\$)	Sublot 4 Quantity L (tons)	Sublot 4 Adjustment (\$)
1000	+560	1000	0	1000	-2240	1000	+280

U = Unit Price for Material, \$/Ton

Quality Assurance Adjustment = L x U x (SCPF – 1.00) / MAF

Figure 5-11. Quality Assurance Adjustment

MIX APPEAL -- QC/QA HMA

If the Producer does not agree with the acceptance test results, a request may be submitted in writing that additional samples be tested. The written request is required to include the Producer's test results and be made within seven calendar days of receipt of the written results of the asphalt mixture tests for that lot. The appeal is not accepted if the Producer has not conducted any tests that indicate a higher Pay Factor than was determined from the test results by INDOT.

Additional tests for the appeal may be requested for the maximum specific gravity, bulk specific gravity of the gyratory specimens, binder content, or bulk specific gravity of the density cores. One or more of these tests may be requested for the subplot or entire lot. Upon approval of the appeal, the backup samples are tested as follows:

- 1) Maximum Specific Gravity -- The sample is dried in accordance with **ITM 572** and mass determined in water in accordance with **AASHTO T 209**.
- 2) Bulk Specific Gravity of the Gyratory Specimens -- New gyratory specimens are prepared and tested in accordance with **AASHTO T 312**.
- 3) Binder Content -- The binder content is tested in accordance with the test method that was used for acceptance or as directed by INDOT.
- 4) Bulk Specific Gravity of the Density Core -- Additional cores are taken within seven calendar days unless otherwise directed. The core locations are determined by adding 1.0 ft longitudinally of the cores tested for acceptance using the same transverse offset. The cores are dried in accordance with **ITM 572** and tested in accordance with **AASHTO T 166**, Method A.

The appeal results replace all previous test result(s) for acceptance of the mixture properties and density.